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ABSTRACT

The ninth report of the Michigan Educational Assessment Program contains the technical information needed to evaluate the instruments and techniques used to measure and report the status of student achievement and attitude. This report is intended for people with expertise in psychometrics. The Program is described in the first section of the report. The second section describes the assessment battery and contains two sub-sections that deal, respectively, with its non-cognitive and cognitive parts. Each sub-section presents a description of the instrument(s) involved, the derivation of reported scores, and the psychometric properties of the measures. Appendix A contains raw and standard score distributions, conversion parameters, and percentile ranks for the tests of basic skills. Appendix B contains basic skills test question classifications. Appendix C contains basic skills test content specifications. (For related document, see TM 002 326-328, 330.) (Author/KM)

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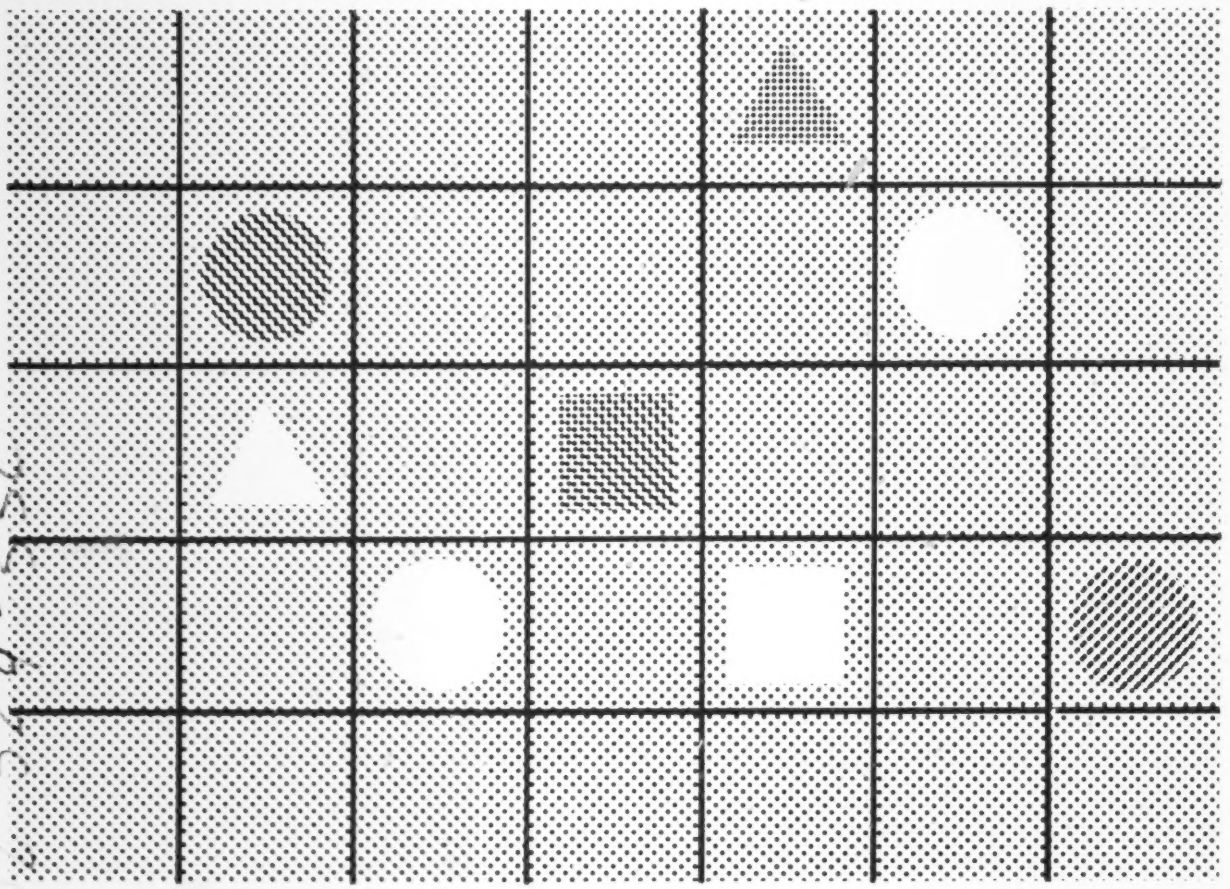
TECHNICAL REPORT

THE NINTH REPORT OF THE 1970-71
MICHIGAN EDUCATIONAL ASSESSMENT PROGRAM



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TECHNICAL REPORT OF THE

1970-71 MICHIGAN EDUCATIONAL ASSESSMENT BATTERY

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TECHNICAL REPORT OF THE
1970-71 MICHIGAN EDUCATIONAL ASSESSMENT BATTERY

Introduction

This is one of a series of reports of the second year of the Michigan Educational Assessment Program which was designed to assess the needs for improved education in the state by providing information upon which sound decisions could be made. The primary function of this report is to set forth the technical information needed to evaluate the instruments and techniques used to measure and report the status of student achievement and attitude. It is intended for people with expertise in psychometrics, such as directors of research, research consultants, and school counselors.

This report is divided into two sections. The first of these contains a brief description of the 1970-71 Assessment Program. The second section describes the assessment battery and contains two sub-sections that deal, respectively, with its non-cognitive and cognitive parts. Each of these sub-sections presents a description of the instrument(s) involved, the derivation of reported scores, and the psychometric properties of the measures.

Background of The Michigan Educational Assessment Program

There are four objectives of the Michigan Educational Assessment Program and specific background information. The following paragraphs will present these objectives for the interested reader.

Objective one states that the Michigan Educational Assessment Program will provide the State Board of Education, the Executive Office, the Legislature and citizens with information which contributes to an understanding of the educational needs of Michigan's school children and the analysis of the educational system's responses to these needs.

Objective two states that the Michigan Educational Assessment Program will provide citizens and educators in every school system with information regarding their district and its schools. This information will contribute to an understanding of the educational needs of their district's school children and the analysis of their district's responses to these needs.

Objective three states that the Michigan Educational Assessment Program will provide school districts with basic information regarding students that will help the students, their parents, and educators to assess their progress. Additionally this information will be used by districts to identify students who have extraordinary need for assistance to improve their competence consistent with the agreed upon performance objectives.

Objective four states that the Michigan Educational Assessment Program will provide citizens of Michigan with information regarding the progress of the Michigan educational system as a whole, and the progress of its school districts and schools over a period of years.

Measures Reported in The Educational Assessment Program

Information was reported on 25 measures in the educational assessment program. The measures were classified into four major categories: school resources, student background, school/student performance, and school or district size. A list of these measures is presented in Table 1. A complete description of each measure is provided in Appendix B of the third report of the 1970-71 educational assessment program, Local District and School Report: Explanatory Materials.

Table 1. Measures and Sources of Basic Data

Measures	Source		
	District	School	Student
I. School Resources			
A. Human Resources			
(1) Pupil-Professional Instructional Staff Ratio*		X	
(2) Pupil-Teacher Ratio		X	
(3) Percent of Teachers with Five or More Years Experience		X	
(4) Average Years of Teaching Experience (1969-70)	X		
(5) Percent of Teachers with Masters Degree		X	
(6) Percent of Teachers Earning $11,000 or More*		X	
(7) Average Salary of Teachers (1969-70)	X		
B. Financial Resources			
(8) State Equalized Evaluation per Resident Pupil (1969-70)	X		
(9) Local Revenue per Pupil (1969-70)	X		
(10) State School Aid per Pupil	X		
(11) K-12 Instructional Expense per Pupil (1969-70)	X		
(12) Total Current Operating Expense per Pupil (1969-70)	X		
II. Student Background			
(13) Percent of Racial-Ethnic Minority Students*		X	
(14) Students' Estimate of Socio-economic Status			X
III. School/Student Performance			
A. Attitude Measures			
(15) Importance of School Achievement			X
(16) Self-Perception			X
(17) Attitude Toward School			X
B. Basic Skills Measures			
(18) Vocabulary			X
(19) Reading			X
(20) Mechanics of Written English			X
(21) Mathematics			X
(22) Basic Skills Composite Achievement			X

*These variables were added since the 1970-70 educational assessment program. Unless otherwise indicated the data is from 1970-71.

Table 1 (Cont'd)

Measures	Source		
	District	School	Student
C. Dropout Rate			
(23) School Dropout Rate* (1968-69)	X		
IV. School or District Size			
(24) Number of Students in School*		X	
(25) District State Aid Membership	X		

*These variables were added since the 1969-70 educational assessment program. Unless otherwise indicated the data is from 1970-71.

The 1970-71 Assessment Battery

The 1970-71 assessment battery consisted of a pupil background and attitude questionnaire and four achievement tests: vocabulary, reading mechanics of written English, and mathematics. Like its 1969-70 predecessor, the battery was developed according to specifications proposed by Educational Testing Service. In 1970-71 the review by panels of Michigan experts consisting of classroom teachers, administrators, university professors, content area specialists, counselors, and a psychologist* were conducted with representatives of the ETS Test Development staff.

Following the suggestions of the panelists, revisions were made in approximately 20 percent of the questions and the achievement tests were lengthened to permit the reporting of reliable scores for individual students; the background and attitude questionnaire was lengthened to increase the reliability of the group scale scores derived from these questions. Table 2 shows the number of questions and the time limits for each section and sub-section of the battery for each grade level.

The assessment battery was administered in January, 1971 to all students who were receiving regular classroom instruction in the content areas of reading, English, and mathematics at the fourth and seventh grade levels in the public schools of Michigan. Table 3 shows the number of districts, schools, and students from or about which information was obtained during the 1970-71 assessment program. The information in that table represents the maximum numbers of units from which data were obtained. Since data for some schools and districts were not available for every variable and schools and districts

*Names and affiliations of panel members are available on request from the Research, Evaluation and Assessment Services, Michigan Department of Education, Lansing, Michigan.

which tested fewer than five students were not included in normative distributions and the computation of correlations, the numbers reported in Table 3 may vary from the numbers of schools and districts reported elsewhere. In addition the numbers of students reported in the normative tables will usually be somewhat lower than the total number of students reported in Table 3 since some students were absent for part of the administrations of the assessment battery.

Table 2. Numbers of Questions and Time Limits for Each Separately-timed Part of the Assessment Battery (by Grade)

	Grade 4		Grade 7	
	Questions	Time	Questions	Time
Background and Attitude	51	*	51	*
Vocabulary	50	20	50	20
Reading	50	35	50	35
Mechanics of Written English				
A. Spelling	15	5	20	6
B. Effectiveness of Written Expression	14	9	14	9
C. Written Usage	14	8	17	8
D. Punctuation and Capitalization	12	8	14	7
(Total Mechanics of Written English)	(55)	(30)	(65)	(30)
Mathematics	40	20	40	20

Table 3. Numbers of Districts, Schools, and Students Participating in the 1970-71 Assessment Program

Grade	No. of Districts	No. of Schools	No. of Students
4	612	2,529	161,599
7	584	902	162,585

*The administration of the Background and Attitude Questionnaire was untimed. All items were read by the test administrator and students were allowed ample time to respond or choose not to respond.

Background and Attitude Questionnaire

With the exception of the first two, the items in this questionnaire were designed to measure at least four aspects of the non-cognitive domain: socio-economic status (SES) and attitudes toward self and school and importance of school achievement. The questions designed to assess socio-economic status indirectly concerned biographical information, educational attainment of parents, quality of housing, family structure and stability, occupation, income, and possessions. The questions designed to assess attitudes are exemplified by the following:

1. "Are you happy most of the time?"
2. "Do you like school?"
3. "Is being a good student important?"

These questions were presented in multiple-choice format and the number of alternative responses per question varied from two to five. Students responded anonymously to this questionnaire. The same questions were asked at both grade levels. The entire questionnaire is presented in Table 4.

Scale and Reported Score Development

Inspection of the questionnaire items shows that those numbered 3 through 29 are related to SES, and those numbered 32 through 51 are related to attitudes (see Table 4). Questions 30 and 31 were assumed to be related to both SES and attitudes. Results later indicated that this assumption was false and the items contributed to only one attitude scale. (The first two questions were included as warm-up items and to facilitate data processing.) Consequently, the first step in score development procedures used for this section of the battery was to divide the questions into two overlapping groups: questions 3 through 31 (SES) and questions 30 through 51 (attitude).

Within each of these groups, the alternatives to each question were assigned numerical values. Alternatives judged to be indications of the most positive response received the greatest weight. The only exception to this procedure involved two sets of questions within the SES group, 3 through 6 and 7 through 10. Each of these sets was treated as one question. The weights thus assigned are shown in Table 4.

Next, two random samples of answer sheets were drawn, approximately 10,000 for each grade. The responses on each of these answer sheets were scored using the a priori weights just described. At each grade level the scored responses to each of the two groups of items were subjected to a principal components factor analysis followed by varimax rotation. The loadings on the interpretable factors that resulted from the analyses of the two-groups of items at each grade are presented in Table 5. As can be seen from that table, the factor loadings are similar across grades and permit identical interpretations.

The similarity of the loadings across grades suggested the hypothesis that one SES and one attitude factor matrix would serve for both grades. This hypothesis was tested by re-doing the principal components analyses on both grades combined and assessing the extent to which the common factor matrix replicated the individual grade matrices. The results indicated a remarkable degree of similarity of both the SES and attitude factor matrices across grades. Therefore a single factor matrix for each set of items was used to estimate scores on the obtained scales.

The clusters of questions identified by a factor analysis may be called a scale inasmuch as the items within any cluster covary jointly. Two such scales were identified by the analysis of items 3 through 31 at each grade

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Table 4. Background and Attitude Questionnaire Items and A Priori Weights

Item	Weight
*3. Did your father go to college?	
(A) Yes	4
(B) No	
(C) I don't know	
4. Did your father finish high school?	
(A) Yes	3
(B) No	
(C) I don't know	
5. Did your father go to high school?	
(A) Yes	2
(B)	
(C) I don't know	
6. Did your father finish the 9th grade?	
(A) Yes	1
(B) No	0
(C) I don't know	
*7 Did your mother go to college?	
(A) Yes	4
(B) No	
(C) I don't know	
8. Did your mother graduate from high school?	
(A) Yes	3
(B) No	
(C) I don't know	
9. Did your mother go to high school?	
(A) Yes	2
(B) No	
(C) I don't know	
10. Did your mother finish the 9th grade?	
(A) Yes	1
(B) No	0
(C) I don't know	
11. Do your parents rent the house or apartment you live in?	
(A) Yes	0
(B) No	1
(C) I don't know	.5
12. Does your house or apartment have a dining room outside the kitchen?	
(A) Yes	1
(B) No	0
(C) I don't know	0
13. How many bedrooms does your house or apartment have?	
(A) None or one	0
(B) Two	1
(C) Three	2
(D) Four	3
(E) Five or more	4
14. How many grownups live in your house or apartment?	
(A) 1	1
(B) 2	3
(C) 3	2
(D) 4	1
(E) 5 or more	0
15. How many children live in your house or apartment? (counting yourself)	
(A) 1 (only me)	4
(B) 2	3
(C) 3	2
(D) 4	1
(E) 5 or more	0

*Each set of items 3-6 and 7-10 was treated as one item by using the "yes" response to the highest level of education completed by each parent.

Table 4. Continued

Item	Weight
16. Did your family move from one house or apartment to another last year?	
(A) Yes	0
(B) No	1
(C) I'm not sure	.5
17. Who acts as your father?	
(A) My real father	4
(B) My stepfather	3
(C) A foster father	2
(D) Some other adult	1
(E) No one	0
18. Who acts as your mother?	
(A) My real mother	4
(B) My stepmother	3
(C) A foster mother	2
(D) Some other adult	1
(E) No one	0
19. How many different schools have you gone to since you started first grade? Count only the schools which you went to during the day.	
(A) One--only this one	4
(B) Two	3
(C) Three	2
(D) Four	1
(E) Five or more	0
20. How many cars and trucks that run does your family have?	
(A) None	0
(B) One	1
(C) Two or more	2
21. Does your family regularly take a newspaper?	
(A) Yes	1
(B) No	0
(C) I don't know	0
22. Does your father have a job?	
(A) Yes	1
(B) No	0
(C) I don't know	0
23. Does your mother have a job?	
(A) Yes	1
(B) No	0
(C) I don't know	0
24. Did you attend nursery school?	
(A) Yes	1
(B) No	0
(C) I don't know	0
25. Did your family go away on a vacation last year?	
(A) Yes	1
(B) No	0
(C) I don't know	0
26. Does your family have a dishwashing machine?	
(A) Yes	1
(B) No	0
(C) I don't know	0
27. Has anyone in your family traveled in an airplane in the last year?	
(A) Yes	1
(B) No	0
(C) I don't know	0
28. Do you own your own wrist watch?	
(A) Yes	1
(B) No	0

Table 4. Continued

Item	Weight
29. Does your family have a typewriter?	
(A) Yes	1
(B) No	0
(C) I don't know	0
30. How good a student does your mother want you to be in school?	
(A) One of the best students in my class	4
(B) Above the middle of my class	3
(C) In the middle of my class	2
(D) Just good enough to get by	1
(E) I don't know	1
31. How good a student does your father want you to be in school?	
(A) One of the best students in my class	4
(B) Above the middle of my class	3
(C) In the middle of my class	2
(D) Just good enough to get by	1
(E) I don't know	1
32. How good a student do you want to be in school?	
(A) One of the best students in my class	4
(B) Above the middle of my class	3
(C) In the middle of my class	2
(D) Just good enough to get by	1
(E) I don't know	1
33. How good a student are you?	
(A) One of the best students in my class	4
(B) Above the middle of my class	3
(C) In the middle of my class	2
(D) Just good enough to get by	1
(E) I don't know	1
34. Is being a good student important?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
35. How good a student do you want to be in reading?	
(A) One of the best students in my class	4
(B) Above the middle of my class	3
(C) In the middle of my class	2
(D) Just good enough to get by	1
(E) I don't know	1
36. How good a student do you want to be in mathematics?	
(A) One of the best students in my class	4
(B) Above the middle of my class	3
(C) In the middle of my class	2
(D) Just good enough to get by	1
(E) I don't know	1
37. How good a student do you want to be in English?	
(A) One of the best students in my class	4
(B) Above the middle of my class	3
(C) In the middle of my class	2
(D) Just good enough to get by	1
(E) I don't know	1
38. Can you do many things well?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5

Table 4. Continued

Item	Weight
39. Do you sometimes feel you can't learn?	
(A) Yes	0
(B) No	1
(C) I'm not sure	.5
40. Do most of your classmates like you?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
41. Do you have a good chance to be successful in life?	
(A) I think so	1
(B) I don't think so	0
(C) I'm not sure	.5
42. Do you like your classmates?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
43. Do you feel that you succeed at most things?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
44. Are you happy most of the time?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
45. Do you like school?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
46. How often do you tell your parents about things that happen in school?	
(A) Just about every day	3
(B) Once or twice a week	2
(C) Occasionally, but not often	1
(D) Never or hardly ever	0
47. Do you like to talk to your parents about school work?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
48. Do you like the time you spend in school on mathematics?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
49. Do you like the time you spend in school on reading?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
50. Do you like the time you spend in school on writing, spelling and grammar?	
(A) Yes	1
(B) No	0
(C) I'm not sure	.5
51. If you had your choice, would you rather go to a school other than this one?	
(A) Yes	0
(B) No	1
(C) I'm not sure	.5

level. The first of these appears to be a measure of family solidarity since the questions that contribute most to this factor involve living with both parents (item 14), one's natural parents (items 17 and 18), home ownership (item 11), remaining in one area (item 16) and therefore attending few different schools (item 19), father being employed (item 22) and family ownership of two or more cars (item 20).

The second scale evolving from the analysis of the SES items was called educational-economic advantage. The questions that contribute most to this second factor include having well-educated parents (item sets 3 through 6 and 7 through 10), living in a fairly large house (items 12 and 13), attending nursery school (item 24), having flown on an airplane (item 27), and family possession of conveniences such as a dishwasher (item 26) and a typewriter (item 29).

Four easily interpretable factor scales emerged from the analysis of the attitude items at each grade level. The first of these reflects attitude toward school achievement. Questions which make the greatest contribution to this scale include how well the student wants to do in school generally and in specific subjects (items 32, 35, 36, and 37) and the student's perception of how well his parents want him to do in school (items 30 and 31). The second scale is a measure of attitude toward school. The questions having high loadings on this factor deal with liking school (item 45), liking to talk about school (items 46 and 47) and liking various subjects (items 48, 49, and 50). Questions contributing most to the third scale, attitude toward self, include those dealing with the student's conception of his general ability (items 33, 38, 39, 41 and 43) and his

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Table 5. SES and Attitude Varimax Factor Loadings

Items	SES I		SES II		Attitude I		Attitude II		Attitude III		Attitude IV	
	Gr. 4	Gr. 7	Gr. 4	Gr. 7	Gr. 4	Gr. 7	Gr. 4	Gr. 7	Gr. 4	Gr. 7	Gr. 4	Gr.
3-6	.12	.19	.57	.57								
7-10	-.06	-.07	.55	.58								
11	.50	.50	.17	.18								
12	-.05	-.06	.38	.38								
13	.08	.12	.36	.35								
14	.43	.52	-.06	-.02								
15	.07	-.01	.04	.08								
16	.50	.42	-.02	-.03								
17	.66	.70	-.10	.02								
18	.44	.34	-.13	-.04								
19	.52	.43	-.05	-.13								
20	.45	.48	.24	.28								
21	.29	.29	.26	.29								
22	.46	.55	.12	.12								
23	-.06	-.01	.16	.07								
24	-.11	-.14	.43	.43								
25	.26	.24	.29	.35								
26	.24	.17	.51	.57								
27	.00	-.05	.48	.53								
28	.23	.18	.20	.21								
29	.25	.19	.42	.43								
30	-.02	.01	.11	.10	.77	.76	.02	-.06	.10	.16	-.03	.0
31	.04	.12	.11	.10	.75	.72	.00	-.08	.08	.14	-.02	.0
32					.75	.78	.05	.19	.11	.09	.08	.0
33					.38	.45	.10	.20	.50	.49	-.07	-.0
34					.22	.31	.08	.25	.05	-.09	.32	.3
35					.74	.74	.05	.21	.09	.06	.10	.0
36					.70	.72	.08	.17	.14	.14	.05	.0
37					.72	.76	.15	.24	.11	.07	.08	.0
38					.12	.12	.03	.03	.68	.65	.05	.0
39					.03	.04	.23	.22	.35	.41	-.26	-.2
40					.02	.06	.02	-.04	.46	.42	.51	.5
41					.17	.18	.08	.08	.54	.56	.20	.2
42					.03	.05	.12	.11	.05	.04	.69	.7
43					.10	.08	.08	.09	.67	.69	.08	.1
44					.01	.02	.19	.18	.30	.28	.51	.5
45					.03	.11	.72	.65	-.01	.05	.18	.2
46					.09	.13	.43	.56	.21	.19	.11	.0
47					.03	.04	.63	.66	.14	.18	.08	.0
48					.06	.08	.59	.44	.13	.15	.01	.1
49					.06	.13	.56	.55	-.04	-.00	.11	.0
50					.07	.05	.70	.63	.03	-.04	.10	.0
51					-.01	.01	.22	.11	-.11	-.05	.46	.5

feeling of being liked by his classmates (item 40). The last scale appears to measure general adjustment, and questions that make the greatest contribution to it involve being liked by and liking one's classmates (items 40 and 42), being generally happy (item 44) and liking the school one is attending (item 51).

Group scores on the obtained scales were estimated by using a weighted average of all the items included in each scale. Each scale for SES or attitudes includes all of the items as shown in Tables 5 and 6. The weights are computed using the factor matrix, and the results of the computations are shown in Table 6. These weights permit the estimation of scores on each scale for a school by multiplying each student's score on each item by the appropriate weight and summing the student scores for each school.

To maintain continuity with the results reported in 1969-70, four average scale scores were reported as a result of this analytic procedure: SES, Importance of School Achievement, Self-Perception, and Attitude Toward School. The reported SES scale score was the mean of the two SES scales: family solidarity and educational-economic advantage. The fourth scale, general adjustment, derived from the attitude items was not reported. This scale was included to improve the factor analyses results of the first three scales.

Table 6. Weights for Questionnaire Items

(Combined Grades)

	SES		Attitude		
Items	I	II	I	II	III
3-6	-0.0032	0.2512			
7-10	-0.0987	0.2736			
11	0.2085	0.0399			
12	-0.0648	0.1923			
13	0.0202	0.1735			
14	0.2166	-0.0734			
15	-0.0101	0.0104			
16	0.2121	-0.0539			
17	0.3143	-0.0910			
18	0.1898	-0.0849			
19	0.2253	-0.0875			
20	0.1814	0.0876			
21	0.0993	0.0980			
22	0.2121	0.0042			
23	-0.0371	0.0582			
24	-0.1109	0.2157			
25	0.0707	0.1239			
26	0.0300	0.2437			
27	-0.0716	0.2436			
28	0.0577	0.0692			
29	0.0522	0.1863			
30	-0.0308	-0.0064	0.2316	-0.0717	-0.0195
31	0.0054	-0.0135	0.2262	-0.0790	-0.0297
32			0.2271	-0.0143	-0.0610
33			0.0580	0.0179	0.2406
34			0.0780	0.0254	-0.1028
35			0.2221	-0.0014	-0.0712
36			0.2045	-0.0268	-0.0268
37			0.2151	0.0257	-0.0672
38			-0.0540	-0.0537	-0.3804
39			-0.0541	0.1203	-0.2325
40			-0.0492	-0.1269	0.2012
41			-0.0240	-0.0445	0.2790
42			-0.0011	-0.0703	-0.0750
43			-0.0676	-0.0293	0.3863
44			-0.0481	-0.0196	0.0941
45			-0.0261	0.2983	-0.0855
46			-0.0248	0.2176	0.0570
47			-0.0534	0.3018	0.0345
48			-0.0308	0.2278	0.0211
49			-0.0025	0.2559	-0.0833
50			-0.0243	0.3085	-0.0801
51			-0.0014	0.0024	-0.1266

Psychometric Properties of the Background and Attitude Questionnaire

Validity. Although no empirical studies have been done on the validity of this questionnaire and the scale scores derived from it, the method of question selection and scale development previously described and an inspection of the questions themselves (see Table 4) indicate that the questionnaire and the resulting scale scores have reasonably high content validity for the purpose of assessing group status and attitudes.

The principal of each school completed a questionnaire which included items regarding the educational training and occupation of the parents of children attending the school. Also included were items concerned with the crowdedness of occupants in the homes, the amount of urban renewal, etc. The correlation between the responses of the principal to these questions and the estimated school SES scores was approximately .80. This indicates substantial agreement between the two measures.

Reliability. To estimate the reliability of the scales derived from the background and attitude questionnaire it would be necessary to readminister the questionnaire to a sample of students. As this was not possible at the time it was decided to attempt to estimate reliabilities by randomly dividing in half the student responses for each school and computing the mean for each half.

If the scales are producing reliable measurements for schools, we would expect the means for each half to be very similar. Thus, the correlation of random halves over schools will provide an estimate of scale reliability. The obtained correlation for composite SES at grade four was .85; the individual scale reliabilities were .75 and .81 for SES, and .52, .54 and .46 for attitude. At the seventh grade the composite SES reliability was .88;

the individual scale reliabilities were .83 and .89 for SES, and .61, .63 and .54 for attitude. (See Table 7.) The reliabilities for the attitude scales are quite low. This may reflect genuine lack of reliability or simply large within-school attitude variability. If the latter is in fact the case, these scales could be useful predictors.

Table 7. Correlations of Composite and Scale Scores between Random Halves of Students Across Schools (by Grade)

	Grade 4	Grade 7
	No. of schools	No. of schools
Scale Scores	2391	838
Composite SES	.85	.88
Family Solidarity	.75	.83
Educational-economic Advantage	.81	.89
Importance of School Achievement	.52	.61
Self Perception	.46	.52
Attitude Toward School	.54	.63

It should be noted that these reliability figures are lower bound estimates. There is simply no way to separate out the inherent lack of reliability of the scales from the variability of the domain being measured. In essence, estimating reliability as has been done assumes a common value to be measured for every student in a school and relegates any lack of similarity between the two halves to instrument unreliability. Of course, the more natural way to measure reliability, i.e., to measure individual students and correlate their two scores, avoids these problems. At any rate, we would expect a priori to obtain higher SES reliability estimates than attitude, since the underlying assumption of a common value to be measured is more likely to hold for SES than attitude within a school.

Tests of Basic Skills

The achievement portion of the assessment battery contained individually timed tests in vocabulary, reading, mechanics of written English, and mathematics. Different forms of the tests were administered at the two grade levels, but they all consisted of four-option multiple-choice questions. The tests are described briefly in the following paragraphs. Time limits for and the number of items in each test will be found in Table 2; content specifications for each test will be found in Appendix C, and item classifications will be found in Appendix B.

The vocabulary test was designed to measure students' knowledge of the meaning of words and the relationships between words and concepts.

The reading test assessed paragraph comprehension, ability to understand words from the context in which they are encountered, and ability to identify the correct synonym for a word.

The mechanics of written English test consisted of four parts: part A, spelling, asked students to identify misspelled words; part B, effectiveness of written expression, required students to select the best way of expressing a thought; part C, written usage, asked students to recognize grammatical errors; and, part D, punctuation and capitalization, asked students to recognize errors of punctuation and capitalization.

The mathematics test involved mathematical reasoning and problem solving. In addition, problems in the seventh grade test involved algebraic and geometric concepts.

Scale and Reported Score Development

The raw score on each of the tests of basic skills is the number of questions the student answered correctly. For each of the four tests at each grade level, the raw score districution was transformed into a standard score distribution with a mean of 50 and a standard deviation of 10. After these transformations, a composite achievement score was computed for each student. It consisted of the average of his standard scores on reading, mechanics of written English, and mathematics. Appendix A presents the raw and standard score distributions, the conversion parameters, and the percentile ranks for each test at each grade level. It also gives the standard score distribution and the percentile ranks for the two sets of composite achievement scores.

Five standard scale scores were reported for each student: vocabulary, reading, mechanics of written English, mathematics, and composite achivement.

Psychometric Properties of the Tests of Basic Skills

At each of the grade levels, 4 and 7, a spaced sample of 1000 answer sheets was drawn from the answer sheets of all the students who participated

in the program. These answer sheets provided the data for determining the psychometric properties of the four achievement tests: vocabulary, reading, mechanics of written English, and mathematics, and where appropriate, for the composite achievement score. Table 8 shows the summary statistics for these tests for both samples and for both total groups. Inspection of that table indicates that the fourth grade sample is slightly less able than the fourth grade total group; all the sample means are a little lower than the total group means. Inasmuch as no difference is as large as one raw score point and the standard deviations are in close agreement, the differences are judged to be of little practical significance. There are no noteworthy or consistent differences between the seventh grade sample and the seventh grade total group.

Table 8. Summary Statistics* on Achievement Tests for Sample and Total Populations

	Grade 4				Grade 7			
	Sample		Total		Sample		Total	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Vocabulary	21.65	8.26	22.11	8.57	27.17	8.24	27.30	8.26
Reading	30.56	10.47	31.03	10.45	31.24	9.83	31.17	9.99
Mechanics of Written English	29.88	10.20	30.67	10.29	33.82	10.14	33.77	10.13
Mathematics	20.98	7.20	21.78	7.29	21.24	7.56	21.42	7.71

The properties of the tests are discussed in the following paragraphs. Tables 9a and 9b present the intercorrelations among the tests at both grade levels, and Table 10 presents data on reliability, speededness, difficulty, and discrimination.

Validity. The content validity of the achievement tests, which is of utmost importance, can be judged by the procedures used in their development and by inspection of the classification of the test questions into various

*In raw score units

segments of the content domain. The development of these tests has been described in an earlier section of this report, test specifications are presented in Appendix C, and classifications of test questions are presented in Appendix B. Examination of these three sources of information indicates that the tests have a high content validity.

The extent to which the tests measure different achievement may be judged by the size of the concurrent validity coefficients reported in tables 9a and 9b. In those tables the intercorrelations among the separately-timed tests at the fourth grade level and at the seventh grade level are shown. The correlations of the scores on the separately-timed section of the Mechanics of Written English Test with the total score are not reported since these correlations are spuriously high because each sub-test contributes to the total score.

The extent to which each sub-test makes a unique contribution to the achievements being measured may be judged by considering the size of the multiple correlation of each sub-test with all the others. For example, the multiple correlations for sub-tests A, B, C, and D are respectively .67, .73, .69 and .66. If there was a large correlation for one sub-test this would indicate that the sub-test was providing no unique information beyond that contributed by those other sub-tests. Using this criterion, it is clear that each of the four sub-tests measures achievement in a subject different from that measured by the other sub-tests.

Reliability. The reliability estimates reported in Table 10 are measures of internal consistency based on a single administration. As such, they reflect primarily the effects of sampling from the content domain. The reliability estimates for the separately-timed parts were computed using

Table 9a. Intercorrelations Among Achievement Tests - Grade 4

Test	Read.	Mechanics of Written English					Math
		A	B	C	D	Total	
Vocabulary	.72	.60	.62	.62	.57	.73	.69
Reading		.66	.72	.66	.64	.81	.75
English: A Spelling			.60	.56	.56	--	.59
B Effect. Exps.				.64	.59	--	.65
C Usage					.53	--	.63
D Punc., Cap.						--	.63
Total							.75

Table 9b. Intercorrelation Among Achievement Tests - Grade 7

Test	Read.	Mechanics of Written English					Math
		A	B	C	D	Total	
Vocabulary	.76	.54	.60	.62	.56	.70	.70
Reading		.63	.66	.65	.62	.78	.69
English: A Spelling			.54	.56	.56	--	.52
B Effect. Exps.				.57	.54	--	.59
C Usage					.60	--	.58
D Punc., Cap.							.63
Total							.70

the Kuder Richardson formula (2); those for the Mechanics of Written English total score and for the composite achievement score were computed using the formula,

$$\text{reliability} = 1 - \frac{\Sigma w^2 \, SE_{meas}{}^2}{\sigma_t{}^2}$$

For the Mechanics of Written English total score, the weights, w were each unity; the standard errors of measurement were those of the four sub-sections; and $\sigma_t{}^2$ was the variance of the total score. For the composite achievement score, the weights were the appropriate A values in the conversion equations (see Conversion Data, Appendix A), the standard errors of measurement were those for the three tests (Reading, Mechanics of Written English, and Mathematics), and $\sigma_t{}^2$ was the composite score variance.

The reliability estimates reported for the sub-tests of the Mechanics of Written English Test range from .66 to .79 indicating that these brief sub-tests are not reliable enough for the assessment of individual students. The estimates reported for the four achievement tests and the composite score, however, range from .86 to .96 indicating that these tests and the composite score are sufficiently reliable* for that purpose. (Table 10)

The standard errors of measurement, which are indices of the reliability of individual test scores, reported in Table 10 are sufficiently low to justify the use of these four tests and of the composite achievement score in the assessment of individual students.

*Remmers, H. H. and Gage, N. L. Educational Measurement and Evaluation, Revised Edition 1955, Harper and Brothers, New York, pp. 140-141.

Table 10 Statistical Properties of Achievement Tests by Grade

Means	Reliability[1]		Standard[2] Error of Measurement		Speededness				Difficulty[3]		Discrimination[4]	
	Gr.4	Gr.7	Gr.4	Gr.7	Gr.4		Gr.7		Gr.4	Gr.7	Gr.4	Gr.7
					% completing	% reaching 3/4 point	% completing	% reaching 3/4 point	%	%		
Vocabulary	.86	.87	3.6	3.0	66.3	84.2	82.7	95.9	43.3	54.3	.42	.46
Reading	.93	.91	2.7	3.0	88.0	97.2	90.4	98.4	61.1	62.5	.59	.54
Written English	.90*	.89*	3.1	3.4	NA	NA	NA	NA	54.3	52.0	.49	.44
A Spelling	.74	.75	**	**	90.4	96.5	92.5	98.1	59.1	50.0	.50	.46
B Effect Exp.	.79	.70	**	**	91.4	96.4	97.1	98.9	60.0	65.5	.56	.49
C Usage	.71	.65	**	**	92.8	97.2	95.5	97.8	44.6	46.8	.46	.39
D Punc. Cap.	.66	.68	**	**	93.6	97.6	94.3	98.2	53.2	47.8	.45	.45
Mathematics	.86	.87	3.7	3.5	87.0	95.5	86.8	96.5	52.5	53.1	.48	.51
Composite Achievement	.96*	.96*	1.85	1.90	NA	NA	NA	NA	NA	NA	NA	NA

1. K-R (20),* See text

2. In standard score units

3. Mean as a percentage of number of items

4. Item-total r_{bis}

** These statistics are not computed as no reporting is performed on these sub-measures.

Speededness. A test is usually judged to be unspeeded if virtually all of the students reach a point three quarters of the way through the test and eighty percent of the students reach the last question. Inspection of the speededness data in Table 10 indicates that the Vocabulary Test was speeded at the fourth grade level. That test at the seventh grade level and the remaining tests at both grade levels were not unduly speeded. While not everyone reached the three quarter point in any test, in each instance more than eighty percent reached the last question.

Difficulty. The data reported for this property of the tests is the average performance of the sample expressed as a percentage of the number of items in the test under consideration. In a test consisting of questions with four alternative answers, middle or average difficulty would be represented by 62.5%. This figures is based on the assumption that "average" students would know the answers to half of the questions and get a quarter of the remaining questions right by guessing.

Inspection of the percentage indicators of difficulty in Table 10 reveals that the majority of the achievement tests, including the sub-tests of Mechanics of Written English, were somewhat difficult for the students at both grade levels. At grade 4, the Vocabulary Test and the English Usage sub-test could clearly be labelled difficult. At both grade levels, the Reading tests and the Effectiveness of English Expression tests were of average difficulty.

Additional information about the difficulty of the fourth grade tests is summarized on page 34 in Appendix A. At the top of this page are frequency distributions of the difficulty index, delta. A 4-choice item that is known by one-half of the group and answered at random by the

remainder would be expected to yield a delta of about 11.7*. The observed mean for Vocabulary exceeds this middle-difficulty reference value by two delta points; Reading is at the middle-difficulty level for the group, on the average; Mechanics of Written English is more difficult by an average of 0.8 delta point; and the Mathematics mean delta is one point above middle difficulty. More important, perhaps, than the average difficulty is the spread of difficulty among the items. When the group to be tested represents a broad range of ability, and when discrimination at both extremes of the ability range is required, then it is necessary that the items cover a very wide difficulty range, for items of middle difficulty for the group as a whole may be altogether too easy for one extreme group and too hard for the other. Here, the upper portion of the item difficulty range appears to be well represented, but there are few items with deltas in the range of 6.0 to 9.0 in most of the tests. The inclusion of even a few items within this range in each test would materially reduce the proportions of scores that fall in the chance area. It should perhaps be noted here that, since the sample is a little less able than the total group, the deltas are slight overestimates, but no mean discrepancy is likely to exceed 0.2 delta point.

Item statistics for the seventh grade tests are summarized on page 38 of Appendix A. At the top of the page are frequency distributions of the difficulty index, delta. The observed means for the four seventh grade tests lie within 11.6 and 12.7, and three are somewhat higher than the

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*A fuller description of the difficulty index, delta, may be found on page 140 of Thorndike, Robert L. (ed.), Educational Measurement Second Edition: Washington: American Council on Education, 1971.

middle-difficulty reference value. Here, the upper portion of the item difficulty range appears to be fairly well represented, but a few additional items with deltas in the range of 6.0 to 9.0 in those parts with high proportions of scores in the chance area would result in fewer such scores.

Discrimination. An indication of the extent to which each test or sub-test discriminates between good and poor students can be found in the last two columns of Table 10. In each instance the index of discrimination reported there is the mean biserial correlation between scores on the entire test and dichotomized (right vs. wrong) item responses. The mean correlations range from .39 for the English Usage sub-test at the seventh grade to .59 for Reading at the fourth grade indicating that the tests and sub-tests possess acceptable to excellent ability to discriminate between good and poor students. (Table 10).

At the bottom of page 34 are distributions of the biserial correlations between item scores and criterion scores for the fourth grade tests. The criterion for the items in the Mechanics of Written English part scores is the 55-item total score. Otherwise, the criterion for each set is the score on the test noted at the top of the same column. Mean values range from .42 for Vocabulary to .59 for Reading. Only 12 of the 195 correlations are under .20.

At the bottom of page 38 are distributions of the biserial correlations between item scores and criterion scores for the seventh grade tests. The criterion for the items in the Mechanics of Written English part scores is the 65-item total score. Otherwise, the criterion for each set is the score on the test noted at the top of the same column. Mean values range from .44 for Mechanics of Written English to .54 for Reading. Only 8 of the 205 correlations are under .20.

APPENDIX A

Tests of Basic Skills
Raw and Standard Score Distributions,
Conversion Parameters, and Percentile Ranks

Michigan Assessment of Basic Skills

Raw and Standard Score Distributions, Conversion Parameters,

and Percentile Ranks

Grade 4

Vocabulary				Reading			
Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval	Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval
48-50	80-83	58	99.96	48-50	66-68	1106	99.3
45-47	77-79	509	99.6	45-47	63-65	8715	93.8
42-44	73-76	1797	98.5	42-44	60-62	18267	82.3
39-41	70-72	3903	96.0	39-41	58-60	20113	69.6
36-38	66-69	6398	92.0	36-38	55-57	18104	58.2
33-35	63-65	9139	86.3	33-35	52-54	15777	48.3
30-32	59-62	11593	78.9	30-32	49-51	13248	40.0
27-29	56-58	13936	70.2	27-29	46-48	11502	32.7
24-26	52-55	16555	59.7	24-26	43-45	10175	26.3
21-23	49-51	19099	47.7	21-23	40-42	9356	20.4
18-20	45-48	21744	34.0	18-20	38-39	9326	14.5
15-17	42-44	22229	20.0	15-17	35-37	9610	8.5
12-14	38-41	17255	9.1	12-14	32-34	7744	3.6
9-11	35-37	9408	3.2	9-11	29-31	4028	1.1
6- 8	31-34	3724	0.8	6- 8	26-28	1276	0.3
3- 5	28-30	1082	0.1	3- 5	23-25	305	0.1
0- 2	24-27	214	0.0	0- 2	20-22	121	0.0
		158643				158773	

M_x = 22.11

σ_x = 8.57

M_y = 50.0

σ_y = 10.0

Md_x = 21.04

(50 items)

Conversion Data

Raw scores converted to scale with mean of 50 and standard deviation of 10 for this group.

A B

Y = 1.1664 X + 24.2072

M_x = 31.03

σ_x = 10.45

M_y = 50.0

σ_y = 10.0

Md_x = 33.04

(50 items)

Conversion Data

Raw scores converted to scale with mean of 50 and standard deviation of 10 for this group.

A B

Y = 0.9568 X + 20.3119

Michigan Assessment of Basic Skills

Raw and Standard Score Distributions, Conversion Parameters,

and Percentile Ranks

Grade 4

Mechanics of Written English				Mathematics			
Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval	Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval
54-55	73-74	172	99.9	40	75	77	99.95
51-53	70-72	1626	98.9	38-39	72-74	820	99.4
48-50	67-69	4622	96.0	36-37	70-71	2523	97.8
45-47	64-66	8648	90.5	34-35	67-68	5043	94.7
42-44	61-63	11867	83.0	32-33	64-65	7593	89.9
39-41	58-60	14106	74.1	30-31	61-63	10473	83.2
36-38	55-57	15204	64.6	28-29	59-60	12307	75.5
33-35	52-54	15153	55.0	26-27	56-57	13521	66.9
30-32	49-51	15171	45.4	24-25	53-54	14114	58.0
27-29	46-48	14619	36.2	22-23	50-52	14345	49.0
24-26	44-45	14150	27.3	20-21	48-49	14216	40.0
21-23	41-43	13103	19.0	18-19	45-46	14176	31.0
18-20	38-40	11722	11.7	16-17	42-43	13647	22.4
15-17	35-37	8997	6.0	14-15	39-41	12454	14.6
12-14	32-34	5776	2.4	12-13	37-38	10148	8.1
9-11	29-31	2663	0.7	10-11	34-35	6940	3.8
6- 8	26-28	798	0.2	8- 9	31-32	3793	1.4
3- 5	23-25	207	0.04	6- 7	28-30	1511	0.4
0- 2	20-22	61	0.00	4- 5	26-27	469	0.1
				2- 3	23-24	144	0.02
		158665		0- 1	20-22	35	0.00
						158349	

M_x = 30.67

σ_x = 10.29

M_y = 50.0

σ_y = 10.0

Md_x = 30.95

(55 items)

Conversion Data

Raw scores converted to scale with mean of 50 and standard deviation of 10 for this group.

$Y = \underset{A}{0.9718} X + \underset{B}{20.1908}$

M_x = 21.78

σ_x = 7.29

M_y = 50.0

σ_y = 10.0

Md_x = 21.73

(40 items)

Conversion Data

Raw scores converted to scale with mean of 50 and standard deviation of 10 for this group.

$Y = \underset{A}{1.3715} X + \underset{B}{20.1348}$

Michigan Assessment of Basic Skills

Raw and Standard Score Distributions, Conversion Parameters,

and Percentile Ranks

Grade 4

Composite Achievement							
Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval	Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval
	72	5	99.997				
	69-71	517	99.7				
	66-68	3388	97.5				
	63-65	9200	91.7				
	60-62	14607	82.4				
	57-59	17536	71.2				
	54-56	17632	60.0				
	51-53	16681	49.4				
	48-50	15524	39.5				
	45-47	14599	30.2				
	42-44	13711	21.5				
	39-41	12801	13.4				
	36-38	11101	6.3				
	33-35	7060	1.8				
	30-32	2396	0.3				
	27-29	403	0.1				
	24-26	77	0.004				
	21-23	7	0.000				
		157245					
M_x = _____	Conversion Data			M_x = _____	Conversion Data		
σ_x = _____	Average of Reading, Mechanics of Written English, and Mathematics scaled scores.			σ_x = _____			
M_y = 50.0				M_y = _____			
σ_y = 9.2				σ_y = _____			
Md_y = 50.7				Md_x = _____			
(Max. poss. score = 72)							

Michigan Assessment of Basic Skills

Frequency Distributions of Original Deltas
and Biserial Correlations, by Sections

Grade 7

Delta	Mechanics of Written English									
	Voc.	Read.		A	B	C	D	Total		Math.
19.0 up ..										
18.0-18.9										
17.0-17.9	3									1
16.0-16.9	4	1			1	1	1	3		4
15.0-15.9	6	3		1	-	1	-	2		1
14.0-14.9	11	4		1	-	5	2	8		5
13.0-13.9	11	4		2	2	4	2	10		8
12.0-12.9	3	11		5	3	-	4	12		7
11.0-11.9	8	8		1	6	2	-	9		.5
10.0-10.9	2	4		2	-	1	2	5		3
9.0- 9.9	2	12		2	2		1	5		4
8.0- 8.9		2		1				1		1
7.0- 7.9		-								1
6.0- 6.9		1								
Total	50	50		15	14	14	12	55		40
Mean	13.7	11.7		12.0	11.9	13.6	12.6	12.5		12.7
σ	2.0	2.1		1.8	1.6	1.6	1.8	1.8		2.3

r_{bis}										
.90-.99										
.80-.89		2								
.70-.79		14								
.60-.69	3	13		5	6	2	1	14		4
.50-.59	13	10		4	5	6	5	20		19
.40-.49	18	6		3	3	-	4	10		9
.30-.39	6	-		1		5	1	7		3
.20-.29	6	2		1		1	-	2		3
.10-.19	2	3		1			-	1		1
.00-.09	2						-	-		1
Negative .							1	1		
Total	50	50		15	14	14	12	55		40
Not Comp.										
Mean	.42	.59		.50	.56	.46	.45	.49		.48
σ	.14	.17		.15	.08	.12	.17	.14		.14

Michigan Assessment of Basic Skills

Raw and Standard Score Distributions, Conversion Parameters,

and Percentile Ranks

Grade 7

Vocabulary				Reading			
Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval	Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval
48-50	75-77	146	99.9	48-50	67-69	3090	98 1
45-47	71-74	1510	99.0	45-47	64-66	9925	91.8
42-44	68-70	4637	96.0	42-44	61-63	14611	82 7
39-41	64-67	9030	90.4	39-41	58-60	16961	72 0
36-38	61-63	13488	81.9	36-38	55-57	17074	61.3
33-35	57-59	17001	71.2	33-35	52-54	16312	51 0
30-32	53-56	19179	59.2	30-32	49-51	14905	41 7
27-29	50-52	19732	46.8	27-29	46-48	13742	33 1
24-26	46-48	19317	34.6	24-26	43-45	12558	25.2
21-23	42-45	18457	23.1	21-23	40-42	11833	17.7
18-20	39-41	16178	12.9	18-20	37-39	10209	11 3
15-17	35-38	11503	5.7	15-17	34-36	8700	5.9
12-14	31-34	5916	1.9	12-14	31-33	5911	2.1
9-11	29-30	2248	0.5	9-11	28-30	2559	0 5
6- 8	24-27	645	0.1	6- 8	25-27	651	0 1
3- 5	21-23	158	0.03	3- 5	22-24	148	0 04
0- 2	17-19	50	0.00	0- 2	19-21	65	0 00
		159195				159254	

M_x = 27.30	Conversion Data	M_x = 31.17	Conversion Data
σ_x = 8.26	Raw scores converted to scale with mean of 50 and standard deviation of 10 for this group.	σ_x = 9.99	Raw scores converted to scale with mean of 50 and standard deviation of 10 for this group
M_y = 50.0		M_y = 50.0	
σ_y = 10.0		σ_y = 10.0	
Md_x = 27.28		Md_x = 32.17	
(50 items)	A B Y = 1.2102 X + 16.9608	(50 items)	A B Y = 1.0006 X + 18 8160

Michigan Assessment of Basic Skills

Raw and Standard Score Distributions, Conversion Parameters,

and Percentile Ranks

Grade 7

Mechanics of Written English				Mathematics			
Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval	Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval
64-65	80-81	5	99.997	40	74	55	99.97
60-63	76-79	294	99.8	38-39	71-73	901	99.4
56-59	72-75	1611	98.8	36-37	69-70	2982	97.5
52-55	68-71	4430	96.0	34-35	66-68	5942	93.8
48-51	64-67	8514	90.7	32-33	64-65	8463	88.4
44-47	60-63	13907	81.9	30-31	61-62	9891	82.2
40-43	56-59	18654	70.2	28-29	59-60	11173	75.2
36-39	52-55	22317	56.2	26-27	56-57	12189	67.5
32-35	48-51	23024	41.8	24-25	53-55	12574	59.6
28-31	44-47	21282	28.4	22-23	51-52	13242	51.2
24-27	40-43	17820	17.2	20-21	48-49	13673	42.6
20-23	36-39	14036	8.4	18-19	46-47	13561	34.1
16-19	32-35	8562	3.0	16-17	43-44	13386	25.7
12-15	29-31	3646	0.7	14-15	40-42	12660	17.7
8-11	25-28	876	0.2	12-13	38-39	10982	10.8
4- 7	21-24	207	0.04	10-11	35-36	8571	5.4
0- 3	17-20	62	0.00	8- 9	33-34	5059	2.2
		159247		6- 7	30-31	2485	0.6
				4- 5	27-29	757	0.1
				2- 3	25-26	166	0.03
				0- 1	22-24	40	0.00
						158752	

M_x = 33.77

σ_x = 10.13

M_y = 50.0

σ_y = 10.0

Md_x = 33.80

(65 items)

Conversion Data

Raw scores converted to scale with mean of 50 and standard deviation of 10 for this group.

A B

$Y = 0.9872 X + 16.6631$

M_x = 21.42

σ_x = 7.71

M_y = 50.0

σ_y = 10.0

Md_x = 21.21

(40 items)

Conversion Data

Raw scores converted to scale with mean of 50 and standard deviation of 10 for this group.

A B

$Y = 1.2965 X + 22.2258$

Michigan Assessment of Basic Skills

Raw and Standard Score Distributions, Conversion Parameters

and Percentile Ranks

Grade 7

Composite Achievement							
Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval	Raw Score X	Standard Score Y	f	Percentile Rank of Lower Limit of Interval
	72-74	81	99.9				
	69-71	1281	99.1				
	66-68	4440	96.3				
	63-65	8645	90.8				
	60-62	12739	82.7				
	57-59	15453	72.8				
	54-56	17087	61.9				
	51-53	17533	50.8				
	48-50	17052	39.9				
	45-47	15961	29.7				
	42-44	14494	20.5				
	39-41	12656	12.4				
	36-38	10355	5.8				
	33-35	6668	1.6				
	30-32	2180	0.2				
	27-29	268	0.02				
	24-26	26	0.003				
	21-23	4	0.000				
		156923					

M_x = _____	Conversion Data	M_x = _____	Conversion Data
σ_x = _____	Average of Reading, Mechanics of Written English, and Mathematics scaled scores.	σ_x = _____	
M_y = 50.1		M_y = _____	
σ_y = 9.1		σ_y = _____	
Md_y = 50.3		Md_x = _____	
(Max. poss. score = 75)			

Michigan Assessment of Basic Skills

Frequency Distributions of Original Deltas
and Biserial Correlations, by Sections
Grade 7

Delta	Mechanics of Written English									
	Voc.	Read.		A	B	C	D	Total		Math.
19.0 up ..										
18.0-18.9						1		1		
17.0-17.9						-		-		1
16.0-16.9	2			4	1	1	1	7		1
15.0-15.9	7	1		2	-	1	1	4		3
14.0-14.9	5	2		2	-	5	1	8		6
13.0-13.9	7	7		3	3	3	5	14		7
12.0-12.9	8	13		2	1	2	4	9		7
11.0-11.9	9	8		2	2	1	1	6		6
10.0-10.9	5	10		1	2	1	-	4		4
9.0- 9.9	1	5		2	3	-	1	6		4
8.0- 8.9	4	1		1	1	2		4		-
7.0- 7.9	2	3		1	1			2		1
6.0- 6.9										
Total	50	50		20	14	17	14	65		40
Mean	12.4	11.6		13.0	11.2	13.4	13.2	12.7		12.6
σ	2.3	1.8		2.7	2.3	2.5	1.7	2.5		2.1

r_{bis}										
.90-.99										
.80-.89										
.70-.79		3			1			1		1
.60-.69	5	20		3	2		1	6		11
.50-.59	16	14		4	5	6	3	18		15
.40-.49	17	5		7	2	3	7	19		6
.30-.39	8	7		5	2	3	2	12		3
.20-.29	4	-		-	1	3	1	5		1
.10-.19		1		1	-	1		2		1
.00-.09					1	-		1		2
Negative .						1		1		
Total	50	50		20	14	17	14	65		40
Not Comp.										
Mean	.46	.54		.46	.49	.39	.45	.44		.51
σ	.11	.13		.13	.16	.18	.10	.15		.15

APPENDIX B

Basic Skills Test Question Classifications

Michigan Assessment - Vocabulary - Form TMT

Grade 4

	Subject	Relationship
1.	Aesthetic	Associated with
2.	Animals	Characteristic of
3.	Tools	Associated with
4.	Sports	Associated with
5.	Abstract	Antonyms
6.	Human Relationships	Relations
7.	Animals	Part-Whole
8.	Tools	Object-Action
9.	Transportation	Part-Whole
10.	General	Associated with
11.	Household	Part-Whole
12.	Human Relationships	Object-Action
13.	Human Relationships	Characteristic of
14.	Abstract	Characteristic of
15.	Weather	Characteristic of
16.	Aesthetic	Object-Action
17.	Human Relationships	Part-Whole
18.	Animals	Cause-Effect
19.	General	Relations
20.	Animals	Characteristic of
21.	Abstract	Antonyms
22.	Human Relationships	Relations
23.	Household	Class-Subclass
24.	Household	Associated with
25.	Weather	Associated with
26.	Aesthetic	Part-Whole
27.	Household	Class-Subclass
28.	Aesthetic	Object-Action
29.	General	Class-Subclass
30.	Animals	Associated with
31.	Household	Part-Whole
32.	Tools	Associated with
33.	Abstract	Object-Action
34.	Measurement	Unit of Measurement
35.	Transportation	Associated with
36.	Geography	Place-Inhabitant
37.	Sports	Associated with
38.	Household	Part-Whole
40.	Animals	Class-Subclass
41.	Human Relationships	Associated with
42.	Human Relationships	Expression of
43.	Human Relationships	Class-Subclass
44.	Human Relationships	Antonyms
45.	Household	Part-Whole
46.	Animals	Part-Whole
47.	General	Class-Subclass
48.	General	Associated with
49.	Sports	Associated with
50.	Household	Associated with

Michigan Assessment - Reading - Form TMT Grade 4

1. Words - synonym
2. Words - association
3. Words - synonym
4. Words - association
5. Words - illustrative
6. Words - illustrative
7. Words - synonym
8. Words - synonym
9. Words - illustrative
10. Words - synonym
11. Words - illustrative
12. Words - synonym
13. Words - synonym
14. Words - synonym
15. Words - synonym
16. Sentences - inference
17. Sentences - straightforward comprehension
18. Sentences - inference
19. Sentences - straightforward comprehension
20. Sentences - inference
21. Sentences - straightforward comprehension
22. Sentences - inference
23. Sentences - straightforward comprehension
24. Sentences - inference
25. Sentences - straightforward comprehension
26. Sentences - inference
27. Sentences - straightforward comprehension
28. Sentences - inference
29. Sentences - straightforward comprehension
30. Sentences - inference
31. Passages - narrative
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact
32. Passages - narrative
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact
33. Passages - narrative
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact
34. Passages - narrative
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact
35. Passages - narrative
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact
36. Passages - narrative
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact

Michigan Assessment - Reading - Form TMT Grade 4 (Continued)

37. Passages - social studies
Items in Passages - interpretive
Alternate Classification of Items in Passages - inference

38. Passages - social studies
Items in Passages - factual
Alternate Classification of Items in Passages - fact

39. Passages - social studies
Items in Passages - factual
Alternate Classification of Items in Passages - fact

40. Passages - science
Items in Passages - factual
Alternate Classification of Items in Passages - fact

41. Passages - science
Items in Passages - factual
Alternate Classification of Items in Passages - fact

42. Passages - science
Items in Passages - interpretive
Alternate Classification of Items in Passages - application

43. Passages - narrative
Items in Passages - interpretive
Alternate Classification of Items in Passages - inference

44. Passages - narrative
Items in Passages - factual
Alternate Classification of Items in Passages - fact

45. Passages - narrative
Items in Passages - interpretive
Alternate Classification of Items in Passages - main idea

46. Passages - narrative
Items in Passages - interpretive
Alternate Classification of Items in Passages - application

47. Passages - science
Items in Passages - factual
Alternate Classification of Items in Passages - fact

48. Passages - science
Items in Passages - interpretive
Alternate Classification of Items in Passages - inference

49. Passages - science
Items in Passages - interpretive
Alternate Classification of Items in Passages - main idea

50. Passages - science
Items in Passages - interpretive
Alternate Classification of Items in Passages - inference

Michigan Assessment - English - Form TMT Spelling Grade 4

1. Spelling by sound alone
2. Misunderstanding rules for word formation
3. No error
4. Spelling by sound alone
5. Spelling by sound alone
6. No error
7. Misunderstanding rules for word formation
8. Spelling by sound alone
9. Misunderstanding rules for word formation
10. No error
11. Spelling by sound alone
12. No error
13. Misunderstanding rules for word transformation
14. No error
15. Spelling by sound alone

Effectiveness of Expression - Grade 4

16 - 29 Questions testing effectiveness of expression ask the student to demonstrate his sensitivity to language by selecting the wording which, in addition to being grammatically correct, is best in sentence structure and word order, and is most precise and appropriate in idiom and diction.

Written Usage - Grade 4

30. Verb forms
31. No error
32. Adjective - adverb confusion
33. Verb forms
34. Other (than/as)
35. Adjective forms (a/an)
36. No error
37. Adjective forms
38. Verb forms
39. Pronoun - antecedent agreement
40. Subject - verb agreement
41. No error
42. Adjective/adverb confusion
43. Pronoun forms

Punctuation and Capitalization - Grade 4

44. Capital letter - first word of sentence, proper noun; period at end of sentence
45. Apostrophe - possessive, contraction
46. Capital letter - first word of sentence, first person I; comma in date

Punctuation and Capitalization - Grade 4 (Continued)

47. Capital letter - first word of sentence; question mark
48. Comma - direct address; capital letter - proper noun
49. Capital letter - proper noun
50. Apostrophe - contraction
51. Period - abbreviation; comma - address
52. Capital letter - proper noun
53. Capital letter - first word of sentence, proper noun
54. Question mark; capital letter - proper noun
55. Comma - in quotation; quotation marks - direct quote

Michigan Assessment - Mathematics - Form TMT Grade 4

1. Number and Operations - operations with integers
2. Geometry and Measurement - properties of polygons and the circle
3. Number and Operations - special properties of zero and one
4. Applications - word problems
5. Geometry and Measurement - angles and intuitive ideas of geometry
6. Number and Operations - operations with integers
7. Number and Operations - place value
8. Mathematical Sentences - inequalities
9. Mathematical Sentences - equations
10. Geometry and Measurement - units of measure
11. Applications - word problems
12. Geometry and Measurement - perimeters and areas of simple polygons
13. Number and Operations - place value
14. Applications - word problems
15. Number and Operations - estimation
    Geometry and Measurement - units of measure
16. Number and Operations - operations with integers
17. Number and Operations - place value
18. Applications - word problems
19. Relations, Functions, Graphs - use of mathematical formula
20. Relations, Functions, Graphs - reading and interpreting graphs
21. Number and Operations - operations with integers
22. Applications - word problems
23. Number and Operations - operations with integers
24. Applications - word problems
25. Logical Thinking - intuitive ideas
26. Applications - word problems
27. Number and Operations - properties of operations
28. Number and Operations - proper fractions
29. Number and Operations - operations with integers
30. Number and Operations - properties of integers, divisibility
31. Number and Operations - special properties of zero and one
32. Geometry and Measurement - scale drawings and maps
33. Number and Operations - operations with integers
34. Number and Operations - proper fractions
35. Mathematical Sentences - equations
36. Number and Operations - proper fractions
37. Number and Operations - properties of operations
38. Number and Operations - proper fractions
39. Applications - word problems
40. Number and Operations - place value

Michigan Assessment - Vocabulary - Form TMT Grade 7

	Subject	Relationship
1.	Tools	Synonyms
2.	Human Relationships	Characteristic of
3.	Aesthetic	Object-Action
4.	Transportation	Relations
5.	Animals	Characteristic of
6.	Sports	Associated with
7.	Household	Class-Subclass
8.	Transportation	Associated with
9.	Human Relationships	Antonyms
10.	Household	Associated with
11.	Human Relationships	Antonyms
12.	Tools	Relations
13.	Animals	Class-Subclass
14.	Aesthetic	Associated with
15.	Household	Relations
16.	Geography	Characteristic of
17.	Household	Associated with
18.	Household	Part-Whole
19.	Household	Part-Whole
20.	General	Object-Action
21.	Human Relationships	Cause-Effect
22.	Sports	Associated with
23.	Human Relationships	Object-Action
24.	Abstract	Antonyms
25.	Tools	Object-Action
26.	General	Associated with
27.	Aesthetic	Characteristic of
28.	General	Antonyms
29.	Human Relationships	Associated with
30.	Tools	Object-Action
31.	Sports	Object-Action
32.	Human Relationships	Characteristic of
33.	Household	Relations
34.	General	Relations
35.	Weather	Cause- Effect
36.	Geography	Associated with
37.	Household	Object-Action
38.	Household	Relations
39.	Tools	Relations
40.	Human Relationships	Antonyms
41.	Abstract	Synonyms
42.	General	Part-Whole
43.	Household	Part-Part
44.	Household	Part-Whole
45.	General	Object-Action
46.	General	Associated with
47.	General	Associated with
48.	Household	Relations
49.	General	Associated with
50.	Household	Class-Subclass

Michigan Assessment - Reading - Form TMT Grade 7

1. Words - association
2. Words - illustrative
3. Words - synonym
4. Words - synonym
5. Words - association
6. Words - synonym
7. Words - association
8. Words - illustrative
9. Words - synonym
10. Words - illustrative
11. Words - association
12. Words - illustrative
13. Words - synonym
14. Words - illustrative
15. Words - synonym
16. Sentences - straightforward comprehension
17. Sentences - inference
18. Sentences - straightforward comprehension
19. Sentences - inference
20. Sentences - straightforward comprehension
21. Sentences - straightforward comprehension
22. Sentences - straightforward comprehension
23. Sentences - inference
24. Sentences - straightforward comprehension
25. Sentences - inference
26. Sentences - straightforward comprehension
27. Sentences - inference
28. Sentences - straightforward comprehension
29. Sentences - inference
30. Sentences - straightforward comprehension
31. Passages - narrative
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact
32. Passages - narrative
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact
33. Passages - narrative
    Items in Passages - interpretive
    Alternate Classification of Items in Passages - inference
34. Passages - science
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact
35. Passages - science
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact
36. Passages - science
    Items in Passages - factual
    Alternate Classification of Items in Passages - fact

Michigan Assessment - Reading - Form TMT Grade 7 (Continued)

37. Passages - social studies
Items in Passages - factual
Alternate Classification of Items in Passages - fact

38. Passages - social studies
Items in Passages - interpretive
Alternate Classification of Items in Passages - inference

39. Passages - social studies
Items in Passages - interpretive
Alternate Classification of Items in Passages - main idea

40. Passages - social studies
Items in Passages - factual
Alternate Classification of Items in Passages - fact

41. Passages - narrative
Items in Passages - factual
Alternate Classification of Items in Passages - fact

42. Passages - narrative
Items in Passages - factual
Alternate Classification of Items in Passages - fact

43. Passages - narrative
Items in Passages - interpretive
Alternate Classification of Items in Passages - inference

44. Passages - social studies
Items in Passages - factual
Alternate Classification of Items in Passages - fact

45. Passages - social studies
Items in Passages - interpretive
Alternate Classification of Items in Passages - inference

46. Passages - social studies
Items in Passages - interpretive
Alternate Classification of Items in Passages - inference

47. Passages - social studies
Items in Passages - interpretive
Alternate Classification of Items in Passages - main idea

48. Passages - science
Items of Passages - factual
Alternate Classification of Items in Passages - fact

49. Passages - science
Items in Passages - factual
Alternate Classification of Items in Passages - fact

50. Passages - science
Items in Passages - factual
Alternate Classification of Items in Passages - fact

Michigan Assessment - Mechanics of Written English - Form TMT Grade 7

Spelling

1. Common mispronunciation
2. Spelling by sound alone
3. No error
4. Misunderstanding rules for word formation
5. Misunderstanding rules for word formation
6. Spelling by sound alone
7. Misunderstanding rules for word transformation
8. No error
9. Misunderstanding rules for word formation
10. Misunderstanding rules for word transformation
11. Spelling by sound alone
12. No error
13. Misunderstanding rules for word formation
14. Misunderstanding rules for word transformation
15. Common mispronunciation
16. No error
17. Common mispronunciation
18. Misunderstanding rules for word transformation
19. Misunderstanding rules for word transformation
20. Misunderstanding rules for word formation

Effectiveness of Expression

21 - 34. Questions testing effectiveness of expression ask the student to demonstrate his sensitivity to language by selecting the wording which, in addition to being grammatically correct, is best in sentence structure and word order, and is most precise and appropriate in idiom and diction.

Written Usage

35. Adjective - adverb confusion
36. Pronoun forms
37. No error
38. Subject - verb agreement
39. Verb forms
40. Verb forms
41. Pronoun - antecedent agreement
42. Verb forms
43. Pronoun forms
44. Adjective form (a/an)
45. Verb forms
46. Subject - verb agreement
47. Adjective forms
48. Adjective - adverb confusion

Michigan Assessment - Mechanics of Written English - Form TMT Grade 7

Written Usage (Cont'd)

49. No error
50. Pronoun - antecedent agreement
51. Adjective - adverb confusion

Punctuation and Capitalization

52. Apostrophe - possessive; comma - compound sentence; capital letter - proper name
53. Apostrophe - possessive; capital letter - proper name; period - abbreviation
54. Capital letter - common/proper noun; apostrophe - contraction
55. Apostrophe - possessive; apostrophe - possessive; question mark
56. Capital letter - common/proper noun; semicolon; capital letter proper name
57. Period - abbreviation; capital letter - proper name; capital letter - common/proper noun; capital letter - common/proper noun
58. Comma - date; comma - date; capital letter - proper noun
59. Capital letter - proper noun; comma - in apposition; period - end of sentence
60. Quotation marks - direct quote; capital letter - in quotation; quotation marks - direct quote
61 Quotation marks - title; unnecessary comma; capital letter - common/proper noun
62. Comma - in quotation; quotation marks - direct quote; comma - in quotation; quotation marks - direct quote; comma - date
63. Capital letter - proper name; period - abbreviation; unnecessary comma
64. Capital letter - common/proper noun
65. Capital letter - common/proper noun; capital letter - proper name; apostrophe - possessive

Michigan Assessment - Mathematics - Form TMT Grade 7

1. Applications - word problems
2. Mathematical Sentences - equations
3. Mathematical Sentences - inequalities
4. Geometry and Measurement - scale drawings and maps
5. Number and Operations - place value
6. Relations, Functions, Graphs - reading and interpreting graphs
7. Number and Operations - proper fractions
8. Number and Operations - special properties of zero to one
9. Geometry and Measurement - units of measure
10. Geometry and Measurement - perimeters and areas of simple polygons
11. Relations, Functions, Graphs - use of mathematical formula
12. Number and Operations - operations with integers
13. Number and Operations - operations with integers
14. Number and Operations - properties of operations
15. Geometry and Measurement - units of measure
16. Geometry and Measurement - properties of polygons and the circle
17. Mathematical Sentences - equations
18. Geometry and Measurement - perimeters and areas of simple polygons
19. Number and Operations - operations with integers
20. Number and Operations - decimals and percents
21. Applications - word problems
22. Logical Thinking - intuitive ideas
23. Geometry and Measurement - scale drawings and maps
24. Applications - word problems
25. Mathematical Sentences - inequalities
26. Number and Operations - properties of integers, divisibility
27. Number and Operations - proper fractions
28. Number and Operations - proper fractions
29. Number and Operations - properties of integers, divisibility
30. Number and Operations - average
31. Relations, Functions, Graphs - reading and interpreting graphs
32. Relations, Functions, Graphs - reading and interpreting graphs
33. Applications - word problems
34. Geometry and Measurement - units of measure
35. Applications - word problems
36. Geometry and Measurement - angles and intuitive ideas of geometry
37. Geometry and Measurement - perimeters and areas of simple polygons
38. Number and Operations - estimation
39. Applications - word problems
40. Number and Operations - decimals and percents

APPENDIX C

Basic Skills Test Content Specifications

Reading Comprehension Test Content Specifications

(1970-71)

	Grade 4	Grade 7
I. WORDS	15 items	15 items
A. Synonymous (BEGIN: start)	9	6
B. Associative (DRY: desert)	2	4
C. Illustrative (RELUCTANT: "I'd really rather not."	4	5
II. SENTENCES	15 items	15 items
A. External - tests word not in sentence but inferred from sentence	8	6
B. Internal - tests word in sentence, underlined or boldfact - straight-forward comprehension	7	9
III. READING COMPREHENSION		
A. Items	20 items	20 items
1. Factual (explicit)	13	13
2. Interpretative (inference)	7	7
B. Passage Content	6 passages	6 passages
1. Narrative	2	2
2. Science	2	2
3. Social Studies	2	2
4. Humanities	0	0

Mechanics of Written English Test Content Specifications

(1970-71)

	Grade 4	Grade 7
I. SPELLING	15 Items	20 Items
A. Misunderstanding of rules for word formation	6	10
B. Misunderstanding of rules for word transformation	2	4
C. Reversing of letters	1	2
D. Common mispronunciation	0	1
E. Spelling by sound alone	5	3
F. Other	1	0
II. EFFECTIVENESS OF EXPRESSION	14 Items	14 Items

Questions testing effectiveness of expression ask the student to demonstrate his sensitivity to language by selecting the wording which, in addition to being grammatically correct, is best in sentence structure and word order, and is most precise and appropriate in idiom and diction.

III. GRAMMAR AND USAGE	14 Items	17 Items
A. Subject-verb agreement	1	2
B. Verb forms	3	4
C. Double negative	0	0
D. Adjective/adverb confusion	2	3
E. Adjective forms (including a-an)	2	2
F. Pronoun forms	1	2
G. Homophones	0	0
H. Pronoun-antecedent agreement	1	2
I. Other	1	0
No error	3	2
IV. PUNCTUATION AND CAPITALIZATION	12 Sentences	14 Sentences
A. Capital letters		
1. First word of sentence	4	0
2. Proper names	6	15
3. First person "I"	1	0
4. In titles	0	0
5. In quotations (grade 7 only)	-	1
B. Period		
1. End of Sentence	1	1
2. Abbreviation	1	3
C. Question Mark	2	1

Mechanics of Written English Test Content Specifications

(1970-71)

IV. PUNCTUATION AND CAPITALIZATION (Cont'd)	Grade 4	Grade 7
D. Comma		
1. Address, date	2	3
2. Direct address	1	0
3. Series	0	0
4. In quotations	1	2
5. Apposition (grade 7 only)	--	1
6. Compound sentences (grade 7 only)	--	1
7. Unnecessary (grade 7 only)	--	2
8. With exclamation (grade 7 only)	--	
E. Quatation Marks		
1. Title of Short Publication	0	1
2. Direct address, direct quote	1	4
F. Apostrophe		
1. Possessive	1	5
2. Contraction	2	1
G. Colon (grade 7 only, optional)*		0
H. Semicolon (grade 7 only, optional)		1

*Not included in 1970-71 battery

Mathematics Test Content Specifications

(1970-71)

		Grade 4	Grade 7
I.	NUMBER AND OPERATIONS	20 Items	16 Items
	A. Operations with integers	7	4
	B. Place value	4	1
	C. Properties of integers, divisibility	1	2
	D. Proper fractions	3	3
	E. Decimals and percents	0	1
	F. Properties of operations (commutative, associative, distributive, closure)	2	2
	G. Estimation	1	1
	H. Special properties of zero and one	2	1
	I. Average	0	1
II.	GEOMETRY AND MEASUREMENT	6 Items	9 Items
	A. Units of measure: length, weight, time temperature, money	2	3
	B. Perimeters and areas of simple polygons	1	3
	C. Scale drawings and maps	1	1
	D. Properties of polygons and the circle	1	1
	E. Angles and intuitive ideas of geometry	1	1
III.	RELATIONS, FUNCTIONS, GRAPHS	2 Items	4 Items
	A. Use of mathematical formula	1	1
	B. Reading and interpreting graphs	1	3
IV.	LOGICAL THINKING	1 Item	1 Item
	A. Intuitive ideas: counterexample reasoning	1	1
V.	Mathematical Sentences	3 Items	4 Items
	A. Equations	2	2
	B. Inequalities	1	2
VI.	Applications	8 Items	6 Items
	A. Word problems (other than those already listed in one of the categories above)	8	6

Note: At least one-third of the problems could be classified as applications.